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DRIVE CIRCUIT CONNECTION STRUCTURE AND  
DISPLAY APPARATUS INCLUDING THE CONNECTION STRUCTURE

FIELD OF THE INVENTION AND RELATED ART

5           The present invention relates to a drive  
circuit connection structure suitable for use in a  
display apparatus, and particularly a connection  
structure including a drive semiconductor device  
connected to a periphery of a transparent substrate of  
10 a display panel constituting such a display apparatus  
and a circuit board connected to the semiconductor  
device for supplying input signals and a power to the  
semiconductor device.

Hitherto, there have been known display  
15 apparatus including flat display devices having  
display electrodes arranged in the form of, e.g., a  
matrix, such as EL display panels and liquid crystal  
display panels of the simple matrix-type and the  
active matrix-type. Such display apparatus have  
20 conventionally included a circuit connection structure  
including a transparent substrate, such as a glass  
substrate or a plastic substrate, provided with  
display electrodes arranged in the form of, e.g., a  
matrix; a flexible tape carrier package (TCP) loaded  
25 with a driver IC by the TAB (tape-automated bonding)  
method; and a print circuit board (PCB, hereinafter  
sometimes called "PCB board"), connected in this

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order.

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Figure 12 and Figure 13 (a view showing an A-A' section in Figure 12) illustrate an example of such a drive circuit connection structure for a flat display panel. Referring to these figures, the connection structure includes TCPs 4ap and 8p loaded with driver ICs (as drive semiconductor circuits) 5p and 9p and copper foil patterns 32 (as output electrodes), glass substrates 1ap and 1bp for a liquid crystal panel 1 having electrode terminals 12p extended to peripheries thereof, and ACFs (anisotropic conductive films or anisotropic conductive adhesive) 31 for heat-bonding the copper foil patterns 32 on the TCPs with the electrode terminals 12p on the glass substrates. Further, PCB boards 3p for supplying a power and control signals to the driver ICs 5p and 9p are connected with copper foil patterns 17 (as input electrodes) of the TCPs 4ap with solder 20p.

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In such a display panel connection structure for a display apparatus as shown in Figures 12 and 13, as the display panel (particularly a liquid crystal panel) is provided with a larger number of display electrodes at a higher density, the connection pitch for connection between the output electrodes of the TCPs and the electrode terminals on the transparent substrates are decreased down to a required pitch of 50  $\mu$ m or smaller. However, according to a method for

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connecting TCP with a substrate as explained with  
reference to Figures 12 and 13, a very sophisticated  
and accurate bonding technique is required for  
ensuring such a minute connection pitch because of a  
5 limitation in size accuracy of TCPs and a deviation  
due to thermal expansion during connection by heat  
bonding of TCPs. Therefore, a connection structure as  
shown in Figure 14 including bonding of driver ICs 5  
to a substrate lbp by a face-down mode has been  
10 proposed <sup>for</sup> ~~or~~ ensuring such a minute connection pitch.

More specifically, referring to Figure 14,  
the connection structure includes a connection by the  
face-down bonding mode of driver ICs 5 with electrode  
terminals extended to peripheries of a pair of glass  
15 substrates lap and lbp of a display panel and with  
input electrodes (not shown) formed on the glass  
substrates lap and lbp. The connection structure  
further includes flat cables 7a, 7b and 7c for  
supplying a drive power and control signals from an  
20 external control circuit.

However, in case where such a connection  
structure as shown in Figure 14 is adopted in a  
display panel of a larger size, particularly a liquid  
crystal display panel of an enlarged size as desired,  
25 in recent years, the substrates lap and lbp retain  
only narrow non-opposing peripheral areas while the  
input electrodes are increased in length, so that the

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input electrodes are caused to have a higher impedance, thus being liable to cause a delay in transmission of drive waveforms to the display or pixel electrodes leading to pixels.

5           In order to obviate the difficulty, it may be conceived of lowering the impedance of the input electrodes by forming the electrodes in a larger thickness, but the realization thereof is difficult in view of the limitations from the production process  
10           and size. Further, the increased impedance of the input electrodes is liable to cause a mal-function of data transfer during transmission of image data for a liquid crystal display panel of a higher definition to driver ICs.

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#### SUMMARY OF THE INVENTION

A generic of the present invention is to solve the above-mentioned problems of the prior art.

A more specific object of the present  
20           invention is to provide a circuit connection structure capable of providing a lower input electrode impedance while ensuring a minute connection pitch.

Another object of the present invention is to provide a display apparatus including such a circuit  
25           connection structure.

According to the present invention, there is provided a circuit connection structure, comprising: a

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first substrate having electrode terminals formed thereon, a semiconductor device having first electrodes and second electrodes with the first electrodes connected to the electrode terminals of the first substrate, a flexible wiring member having thereon a pattern of conductors each extending from a first end to a second end on the flexible wiring member with the first ends of the conductors connected to the second electrodes of the semiconductor device, and a circuit board having thereon electrode terminals connected to the second ends of the conductors on the flexible wiring member.

It is preferred that the first and second electrodes of the semiconductor device are used as output electrodes and input electrodes, respectively, of the semiconductor device, so as to receive input data from the circuit board and supply output signals to the first substrate, thereby driving an electronic device including the first substrate.

The flexible wiring member may alternatively be constituted by a plurality of conductor wires each extending from a first end to a second end and not carried on a carrier film.

According to another aspect of the present invention, there is provided a display apparatus, comprising:

a display panel comprising at least one

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substrate having thereon pixel electrodes extending to form electrode terminals electrodes on a peripheral side of the substrate,

a semiconductor device having input  
5 electrodes, and output electrodes for supplying drive waveforms to the pixel electrodes of the display panel, and

a circuit board having electrode terminals for supplying an electric power and control signals to  
10 the semiconductor device; wherein

the electrode terminals on said at least one substrate of the display panel are connected to the output electrodes of the semiconductor device, and

the semiconductor device is connected to the  
15 circuit board via a flexible wiring member having thereon a pattern of conductors each extending from a first end to a second end so that the input electrodes of the semiconductor device are connected to the first ends of the conductors on the flexible wiring member,  
20 and the second ends of the conductors of the flexible wiring member are connected to the electrode terminals of the circuit board.

According to the circuit connection structure of the present invention, the first electrodes on one  
25 side of the semiconductor device may be connected to the electrode terminals on the first substrate which may carry pixel electrodes thereon via, e.g., an

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anisotropic conductive adhesive (ACF), etc., and  
without via a flexible wiring member according to the  
TAB method, thereby ensuring a minute connection  
pitch. On the other hand, the second electrodes on  
5 the other side of the semiconductor device are  
connected via conductors of the flexible wiring member  
to the electrode terminals of the circuit board.  
Particularly when the first and second electrodes of  
the semiconductor device are used as the output and  
10 input electrodes, respectively, the semiconductor  
device can be supplied with an electric power and  
control signals at a low impedance from the circuit  
board through the flexible wiring member and the  
second electrodes, and can supply output signals  
15 through the first electrodes at a minute arrangement  
pitch suitable for a high-definition output.

Particularly, if the circuit connection  
structure is included in a driver IC connection  
structure for a display apparatus including the first  
20 substrate as a substrate carrying pixel electrodes of  
a display panel and the circuit board for supplying an  
electric power and control signals to the driver IC,  
the semiconductor device can be supplied with input  
data at a low impedance and without mal-function and  
25 can supply drive signals to the display panel through  
the first electrodes arranged at a minute connection  
pitch suitable for a higher definition display.


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These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings, wherein like parts are denoted by like reference numerals.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a plan view of a display apparatus including a drive circuit connection structure according to a first embodiment of the invention.

 Figure 2 is a partial sectional view taken along a line A-A' in Figure 1.

Figures 3A - 3C are partial plan views for illustrating steps of bonding a driver IC onto a flexible wiring member in the display apparatus of Figures 1 and 2.

Figure 4 is a side sectional view of a resultant connection structure including the driver IC and the flexible wiring member connected to each other after the steps of Figures 3A - 3C.

Figures 5 - 6 and 8 - 10 are partial sectional views of display apparatus including drive circuit connection structures according to second to sixth embodiments, respectively, of the invention.



Figure 7 is a sectional view of a partial connection structure incorporated in the embodiment of Figure 8.

Figure 11 is a block diagram of a liquid crystal display apparatus.

Figure 12 is a plan view of a liquid crystal display apparatus including a drive circuit connection structure.

*sub D3* Figure 13 is a partial sectional view taken along a line A-A' in Figure 12.

Figure 14 is a partial sectional view of a liquid crystal display apparatus including another drive circuit connection structure.

15 DESCRIPTION OF THE PREFERRED EMBODIMENTS

*sub D4* Figure 1 is a plan view of a liquid crystal display apparatus, as an embodiment of display apparatus, including a drive circuit connection structure according to a first embodiment of the present invention, and Figure 2 is a sectional view taken along a line A-A' in Figure 1. In Figures 1 and 2, reference numerals identical to those used in Figures 12 - 13 denote identical or like parts as in Figures 12 - 13.

25 Referring to Figures 1 and 2, a liquid crystal display apparatus 1 includes a pair of transparent substrates 1a and 1b of, e.g., glass, a

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polarizer 2 (which sandwiches the liquid crystal panel 1 together with a polarizer (not shown) on an opposite side), circuit boards 3 and 10 (of, e.g., a multi-layered glass epoxy PCB board) for supplying a drive power and control signals to driver ICs 5 and 9, flexible wiring members 4a and 8, flat cables 6 for supplying data signals to the circuit boards 3, and a flat cable 7 for supplying a drive power and control signals from an external control circuit (not shown). Referring to Figure 2, a liquid crystal 11 (which is a ferroelectric liquid crystal in this embodiment but can also be a nematic liquid crystal, etc.) is disposed between the substrates 1a and 1b.

The substrates 1a and 1b are provided with electrodes for applying a drive voltage to the liquid crystal 1, and at least one thereof is provided with display electrodes or pixel electrodes leading to or defining the pixels and supplying display data signals to the respective pixels. The pixel electrodes extend to non-opposing peripheries of the substrates 1a and/or the substrate 1b to form electrode terminals thereat. In this embodiment, both substrates 1a and 1b are provided with pixel electrodes so as to form a simple matrix electrode structure suitable for driving the ferroelectric liquid crystal including, e.g., data electrodes on the substrate 1a and scanning electrodes on the substrate 1b, and the pixel electrodes are



extended to non-opposing peripheries of both substrates 1a and 1b to form electrode terminals 12 thereat.

Each driver IC 5 is connected to electrode terminals 12 formed on the glass substrate 1b and extended to a peripheral side of the glass substrate 1b, and the input electrodes of the driver IC 5 are provided in advance with gold bumps 15 to which first ends of conductors on a flexible wiring member 4a are connected by the TAB method, and second (the other) ends of conductors on the flexible wiring member 4a are connected to electrode terminals of the circuit board 3.

At the time of assembling the display apparatus, each driver IC 5 is connected to the glass substrate 1b by first positionally aligning projection electrodes 13 (of, e.g., gold bumps formed on the output electrodes) of the device IC 5 with the electrode terminals 12 on the glass substrate 1b and connecting the projection electrodes 13 and the electrode terminals 12 via an anisotropic conductive adhesive 14 under application of heat and pressure. The projection electrodes 13 (of e.g., gold bumps) may be formed at a minute connection of preferably 50  $\mu$ m or smaller as shown in Figures 3A - 3C described hereinafter.

By connecting the driver IC 5 provided with



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anisotropic conductive adhesive 18 for connecting the copper foil electrodes 17 on the flexible wiring member 4a and the connection electrodes 19 of the circuit board 3, may respectively be composed by  
5 selecting electroconductive particles and an adhesive suitable therefor and need not be identical to each other.

More specifically, in the above-described embodiment, a commercially available anisotropic  
10 conductive film (ACF) may be used as the anisotropic conductive adhesive 18. Generally, however, the anisotropic conductive adhesive 18 may comprise a liquid insulating adhesive of heat-curable type or UV-curable type containing electroconductive particles  
15 dispersed therein. Alternatively it is also possible to use such a liquid insulating adhesive together with gold bumps formed on the electrode terminals. Examples of the electroconductive particles may include Ni-plated or Ni-Au-plated resin particles of 2  
20 - 5  $\mu\text{m}$  in diameter for output electrode connection and Ni particles or Au-plated Ni particles of 5 - 10  $\mu\text{m}$  in diameter for input electrode connection.

In the embodiment shown in Figure 1, the circuit connection structure characteristic to the  
25 present invention as described above is applied to peripheral sides of only one substrate 1b of the display panel 1, and at a peripheral side of the other

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substrate 1a, drivers IC 9 are connected via a TCP with respect to both input side and output side thereof similarly as in the case of Figure 12.

However, it is also possible to adopt the circuit connection structure having a sectional structure as shown in Figure 2 for bonding the driver ICs 9 to the substrate 1a similarly as the driver ICs 5 connected to the substrate 1b.

Then, a flexible wiring member 4a may be connected to a driver IC 5 by the TAB method, for example, in the following manner.

First of all, as shown in Figure 3A, an aperture 24 is formed in a film carrier 4 of, e.g., polyimide or polyethylene terephthalate of ca. 25 - 125  $\mu\text{m}$  in thickness, and tin-plated copper foil conductors 17 and 17a are formed thereon. Then, gold bumps 15 (Figure 2) formed on input electrodes of the driver IC 5 are positionally aligned with the copper foil patterns 17 and 17a and subjected to inner lead bonding by means of a bonding tool. Instead of the above-mentioned tin plating of, e.g., 0.2 - 0.6  $\mu\text{m}$  in thickness, it is also possible to use 0.2 - 10  $\mu\text{m}$ -thick solder, 0.2 - 0.9  $\mu\text{m}$ -thick gold or 0.2 - 10  $\mu\text{m}$ -thick Ni for coating the copper foil conductors 17 and 17a.

The copper foil patterns 17a are used as support patterns for fixing the driver IC and

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connected to dummy gold bumps (not shown) formed on the driver IC 5. However, it is also possible to dispose additional input electrodes there that can be connected to and receive signals from the flexible wiring member 4a.

Then, as shown in Figure 3B, only the input side of the driver IC ~~4~~<sup>5</sup> is sealed with a resinous sealing agent 16. Then, an unnecessary portion of the flexible wiring member 4a is removed by punching to leave a connection structure having a planar structure as shown in Figure 3C and a sectional structure as shown in Figure 4.

In this instance, the gold bumps (projecting electrodes) 13 on the output electrodes of the driver IC may preferably be flattened by the bonding tool at the time of the inner lead bonding or by pressing with another flattening pressure member so as to provide a uniform projection height, in order to provide a reliable bonding between the electrode terminals 12 and the output electrodes 5 of the driver IC 4 with an anisotropic conductive adhesive 14.

In a preferred example of circuit connection structure adopted for constituting a liquid crystal apparatus, each driver IC may have ca. 30 - 60 input electrodes (second electrodes) arranged at a pitch of ca. 100 - 500  $\mu$ m in both cases of constituting a data signal side IC and a scanning signal side IC.

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Further, each driver IC may have ca. 200 - 500 output electrodes (first electrodes) arranged at a pitch of ca. 20 - 60  $\mu\text{m}$  when used as a data signal side IC and at a pitch of ca. 100 - 300  $\mu\text{m}$  when used as a scanning signal side IC. The circuit connection ~~structure~~ <sup>structure</sup> according to the present invention may be adopted for both data signal side ICs and scanning signal side IC but may preferably be used at least for data signal side ICs requiring output electrodes (first electrodes) arranged at a higher density in the embodiment of Figure 1.

Further to say, in a drive system using a liquid crystal showing bistability, such as a ferroelectric liquid crystal, an anti-ferroelectric liquid crystal or a BTN-mode liquid crystal driven in a binary mode, an areal gradational display mode according to a pixel division may be used, thus requiring an increased number of electrodes corresponding to the pixel division and arrangement of driver ICs and output electrodes at a higher density. In such cases, the circuit connection structure according to the present invention may preferably be used not only for data signal side ICs but also for scanning signal side ICs.

Figure 5 is a partial sectional view of a liquid crystal display apparatus including a drive circuit connection structure according to a second

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embodiment of the present invention, wherein copper foil patterns 17 and connection electrodes 19 on a circuit board 3 are connected with a solder 20. Other members denoted by identical numerals as in Figure 2 represent identical or like members as in Figure 2, and 23 represents an aperture formed in a polyimide film carrier 4 at the soldering portion.

Figure 6 is a partial sectional view of a liquid crystal display apparatus including a drive circuit connection structure according to a third embodiment of the present invention, wherein the connection structure is protected by a resinous sealing agent 21 and reinforced by a reinforcing plate 22. In this instance, after applying the resinous sealing agent 21, the reinforcing plate may be bonded to the glass substrate 1a and the circuit board 3 from the back sides, so as to prevent the breakage of the electrical connection even when a stress is applied to the circuit board 3. It is particularly preferred to adopt the reinforcement structure with the reinforcing plate 22 in case where one side of electrodes (output electrodes in this embodiment) of the driver IC 5 are bonded to electrode terminals on the substrate 1b without using a flexible wiring member as in this embodiment.

Figure 7 is a sectional view a drive circuit connection structure according to a fourth embodiment

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of the present invention, wherein a <sup>driver</sup>~~driver~~ IC 5 is connected to a flexible wiring member 4a with an anisotropic conductive adhesive 26. The connection structure may be incorporated in a liquid crystal display apparatus having a sectional structure as shown in Figure 8, wherein the projecting electrodes 13 of the driver IC 5 are thermally pressure-bonded to electrode terminals 12 on the glass substrate 1b via an anisotropic conductive adhesive 14, and conductors 17 on the flexible wiring member 4a are thermally pressure-bonded to connection electrodes 19 on a circuit board 3.

In Figure 8, the conductors (copper foil patterns) 17 are disposed on an upper surface of the flexible wiring member 4a, and correspondingly the circuit board 3 is disposed above the flexible wiring member 4a (on the side having the conductors 17).

Figure 9 is a partial sectional view of a liquid crystal display apparatus including a drive circuit connection structure according to a fifth embodiment of the present invention, wherein a reinforcing plate 30 is disposed along and bonded to the circuit board 3, the driver IC 5 and another substrate 1a in a structure similar to the one shown in Figure 8. The resultant structure is resistant to a stress applied to the circuit board 3, etc., thus being able to avoid a breakage of the electrical



connection similarly as in the embodiment of Figure 6.

Figure 10 is a partial sectional view of a liquid crystal display apparatus including a drive circuit connection structure according to a sixth  
5 embodiment of the present invention, wherein electrode terminals 12 on the glass substrate 1b and the projecting electrodes 13 on the driver IC 5 are thermally pressure-bonded to each other via an anisotropic conductive adhesive 14 after positional  
10 alignment therebetween, input electrodes 29 of the driver IC 5 are electrically connected to connection electrodes on the circuit board 3 with conductive wires 28, and a reinforcing plate 30 is provided to fix the glass substrate 1a, the driver IC and the  
15 circuit board 3 by bonding similarly as in Figure 9.

Finally, an organization of a liquid crystal display apparatus including a liquid crystal display panel as described above together with a control system thereof will be briefly described with  
20 reference to a block diagram of such a liquid crystal display apparatus, for example, shown in Figure 11.

Referring to Figure 11, a liquid crystal display apparatus, such as a color display apparatus, may include a liquid crystal panel 1 as described  
25 above according to the present invention, to which are connected a scanning signal application circuit 402 and a data signal application circuit 403 which are

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sequentially connected to a scanning signal control circuit 406 and a data signal control circuit 407, a drive control circuit 404 and then to a graphic controller 405. From the graphic controller 405,  
5 video data and a scanning scheme signal are supplied to the scanning signal control circuit 406 and the data signal control circuit 407 via the drive control circuit 404.

The video data is converted into scanning  
10 line address data and display data by the scanning signal control circuit 406 and the data signal control circuit 407, and the scanning scheme signal is supplied as it is to the data signal application circuit 402 and the data signal application circuit  
15 403.

The scanning signal application circuit 402 applies a scanning signal determined by the scanning scheme signal to the scanning electrodes in a sequence determined by the scanning line address  
20 data, and the data signal application circuit 403 applies data signals having waveforms determined by a combination of the display data determining white or black display states and the scanning scheme signal to the respective data electrodes. These data signals  
25 and scanning signals are supplied via flat cables 6 and 7 to circuit board 3 and 10, whereby a picture display may be performed on the liquid crystal panel

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1 as shown in Figure 1.

In the above, the circuit connection structure according to the present invention has been described principally as one suitably used in a liquid crystal display apparatus but may also be suitably incorporated in other display apparatus inclusive of those including self-light emission-type flat display panels as represented by an EL-display panel and a plasma display panel.

10 As described above, according to the present invention, by connecting electrode terminals disposed on a peripheral side of a display panel to first electrodes on one side of a drive semiconductor device with, e.g., an anisotropic conductive adhesive, the  
15 electrode terminals and the drive semiconductor device may be connected without a flexible wiring member, thus ensuring a small connection pitch.

On the other hand, second electrodes on the other side of the drive semiconductor device may be  
20 connected to a flexible wiring member, and the flexible wiring member is connected to a circuit board on a supply side with a solder or an anisotropic conductive adhesive, the power and signal can be  
25 supplied to the driver semiconductor device at a low impedance. As a result, even if a display panel, such as a liquid crystal display panel, is enlarged in areal size and driven at a higher speed, drive

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waveforms can be transmitted to pixel electrodes of  
the display panel without transmission delay or  
deformation of drive waveforms. Further, in case of  
supplying picture data for a display panel of a higher  
5 definition it is possible to obviate a mal-function  
during data transmission.

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